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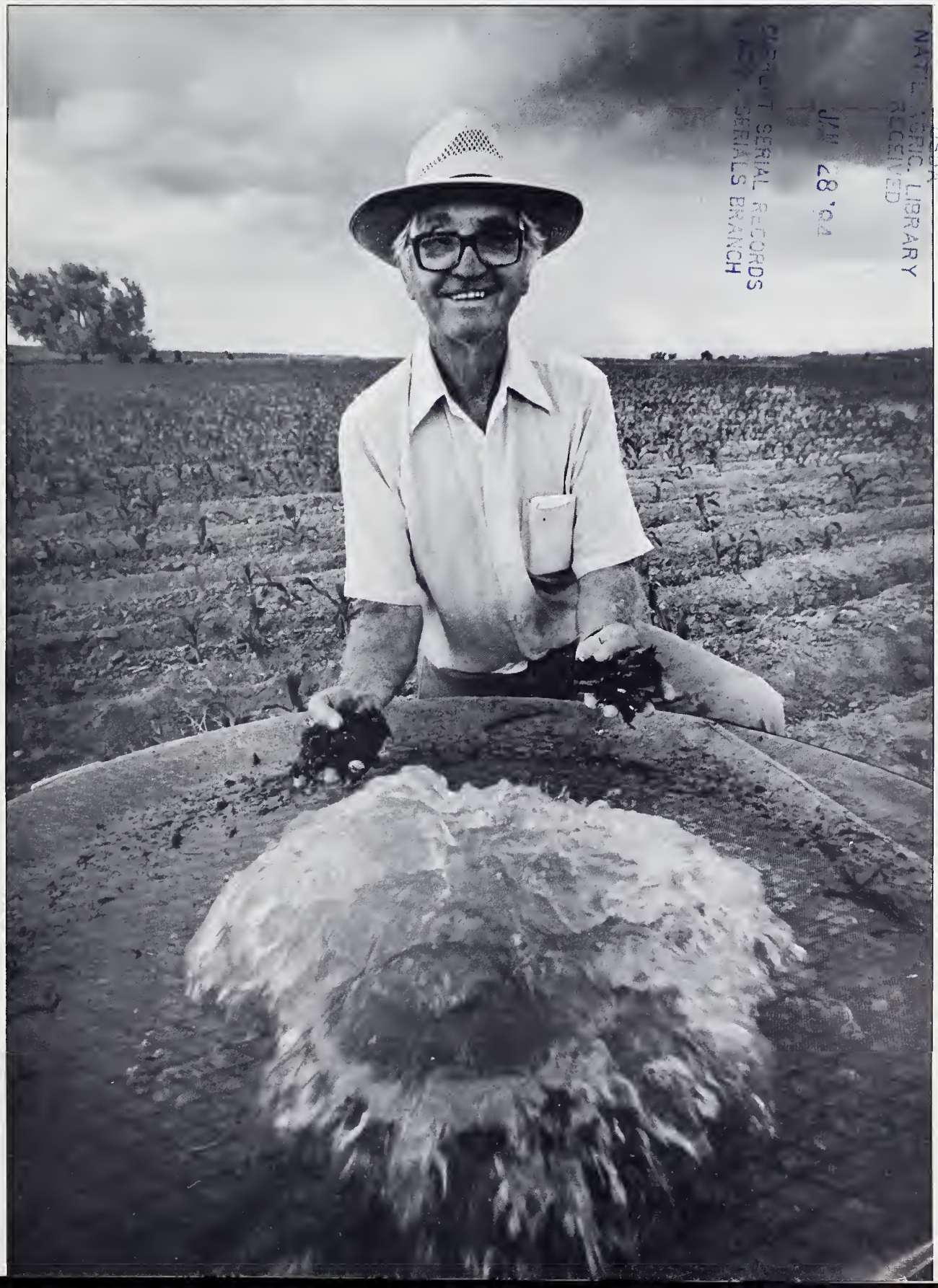
Agricultural Research



Research to Improve Irrigation and Drainage

Theoretically, the United States has plenty of fresh water, either in groundwater supplies, in reservoirs and lakes, or in the form of rain and snow, to more than meet the 450-billion-gallon-per-day annual demand of agriculture, industry, and urban centers. However, this encouraging fact has little to do with the actual supply and demand situation in any given area of the United States.

Many urban areas, including New York City and Los Angeles, must import their water from distant mountains. And agriculture has diverted water from streams and rivers to create lush fields out of barren deserts.

Where excess water is a problem, dams and huge earthen dikes protect against flooding. On farm lands, drainage ditches and buried pipes and tiles take off the excess.

And nature continues to be unpredictable. As happened this past winter, above-average precipitation fell on most areas of the United States. Only a few years earlier, California and other areas were in the midst of a drought.

A fact of life today in using and controlling water is that new efforts can be costly. One of these proposals is the tapping of the vast fresh water supplies in Alaska, diverting it via canals through Canada to water-deficient areas of the Western United States. Another is an immense drainage system for California's San Joaquin Valley to collect saline water and pump it over the Coastal Mountain Range into the Pacific Ocean. Either of these projects could cost several billion dollars.

What can research do to prevent the loss of crops—especially on land that needs to be irrigated or drained? ARS scientists at 16 locations in 14 States are helping to answer these questions. Their goal is to reduce farming risks and increase production efficiencies to insure food supplies for both domestic and foreign markets.

ARS scientists recently have improved irrigation efficiency in several ways. In California, Arizona, Idaho, and Colorado, they have developed automatic and computer-operated irrigation devices that deliver precise amounts of water to crops only when they actually need it. This equipment saves labor and insures efficient use of limited water supplies. Near Fresno, Calif., a buried trickle irrigation system, where plastic tubing delivers water directly to the plant root zone, increased tomato yields up to 76 tons per acre—a 13 to 31-ton advantage over conventional furrow irrigation.

ARS scientists in California found ways to reduce amounts of irrigation water and use saline water diluted with high-quality water, but still obtain acceptable yields of cotton.

Scientists also have uncovered clues that plants give when they need water, and new technology is making a science out of deciding when to irrigate. For example, a hand-held thermometer compares the temperature of plant leaves to the temperature of surrounding air. A difference between the readings can indicate that plants are not able to obtain enough water from the soil to offset the loss of water by evaporation. Such advance warning alerts irrigators so they can apply water before plants interrupt their growth.

While some scientists are greatly concerned about insufficient water, others are more concerned about what to do with excess water.

In Louisiana, installation of subsurface drainage tiles, which lowered the water table below root zones, resulted in wheat yields that were 73 percent higher than yields on undrained areas. Corn silage yields were similarly higher on the drained fields. And because surface water runoff from drained areas was reduced, so too were soil losses.

ARS scientists in Maine significantly increased forage production on land that needed drainage. Another benefit was a 3-week increase in the growing season as well as better protection against frost-heaving damage.

These advancements were not by accident. The combined expertise of ARS scientists nationwide—coupled with assistance from cooperating land-grant universities, private industry, and individual farmers and ranchers—results in the largest, most efficient research system in the world.

What lies ahead is the need to channel resources to overcome the challenges of water shortages, water excesses, and to a limited degree, the whims of nature.

Terry B. Kinney
ARS Administrator

World Food Day, 1983

World Food Day, October 16, highlights the two-way nature of U.S. agriculture: It reminds our citizens that there is still a global need to solve food and hunger problems. And, the day also draws attention to U.S. agriculture's contributions over the years to the fight against malnutrition and starvation worldwide.

Agricultural research and technology in the United States has helped to bolster food supplies for the one-third of the world's population that is dependent on grains as nutritional staples.

Not only have other nations looked to us for crops to fill food bins, but also for farming techniques such as water-saving irrigation practices and new ways to increase soil productivity.

And research continues to explore and discover the different ways agriculture can ease the burden of hunger everywhere.

Within the Agricultural Research Service, some of the latest research results point to exciting possibilities ahead. A few examples: chemical pruning of foliage on apple trees that helps the trees grow fruit instead of wood; preserving embryonic insect cells in ultracold storage for developing future biological controls; and experimenting with a wheat root fungus that may help wheat crops survive drought.

Every day, through these and hundreds of other research projects, ARS upholds the purpose of World Food Day—to create a world free from hunger and malnutrition.

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Cover: Earl Heidel, a farmer in Castleford, Idaho, smiles with satisfaction at how well his newly installed turbulent fountain trash screen removes litter from his irrigation system. The screen was developed by ARS scientists in cooperation with county extension agents and the USDA Soil Conservation Service. Article begins on p. 4. (0782X774-10A)

Turbulent Fountain Screen Cleans Irrigation Water

Above: Agricultural engineer James Bondurant demonstrates how debris removed from irrigation water collects around the periphery of the screen before being washed off. (0782X775-29)

Top right: A turbulent fountain trash screen would keep the gates in irrigation pipes from becoming clogged, like several of those shown here; and the labor savings would pay for the system within one growing season. (0782X771-19)

Right: Organic matter and snail shells from irrigation ponds and canals are plugging the small opening of this gated pipe outlet. (0782X767-3)

Trash removal is a nuisance not limited to urban environs. For growers who irrigate, removing trash such as leaves and straw from irrigation water is more than a nuisance, it is a major problem. ARS researchers believe they now have a remedy for this problem.

After testing several conventional trash screens, soil scientists W. Doral Kemper and agricultural engineer James A. Bondurant, Kimberly, Idaho, have devised a self-cleaning trash remover which they call a "turbulent fountain" screen.

With the turbulent fountain screen, the irrigation water is pushed up a vertical pipe that empties out above the center of the screen. Just before discharge, the water strikes a deflector vane which causes turbulence.

As it bubbles out of the vertical pipe,

Left to right. Snake River Center Director Doral Kemper, county extension agent Dale Bucks, Bondurant, and ARS technician Jeff Breeding connect a trash screen to farmer Earl Heidel's gated pipe system. (0782X755-28)

the water spills over the trash screen and falls back down into the conveyance system. The trash collects on the top of the screen and the spattering water pushes it outward and eventually off the screen.

With no mechanical parts, the turbulent fountain screen is cheaper to install and use, lasts longer, and does a better job of keeping trash off the screen than conventional screening systems.

"Throughout an entire summer of use," says Kemper, "the two turbulent fountain trash screens we tested required no manual cleaning except on two occasions when flow rates were reduced and turbulence was eliminated."

Trash is exceptionally troublesome for those who use sprinkler, gated pipe, or siphon-tube irrigation systems. It can stop or seriously impede the flow of water through such systems, resulting in poor irrigation.

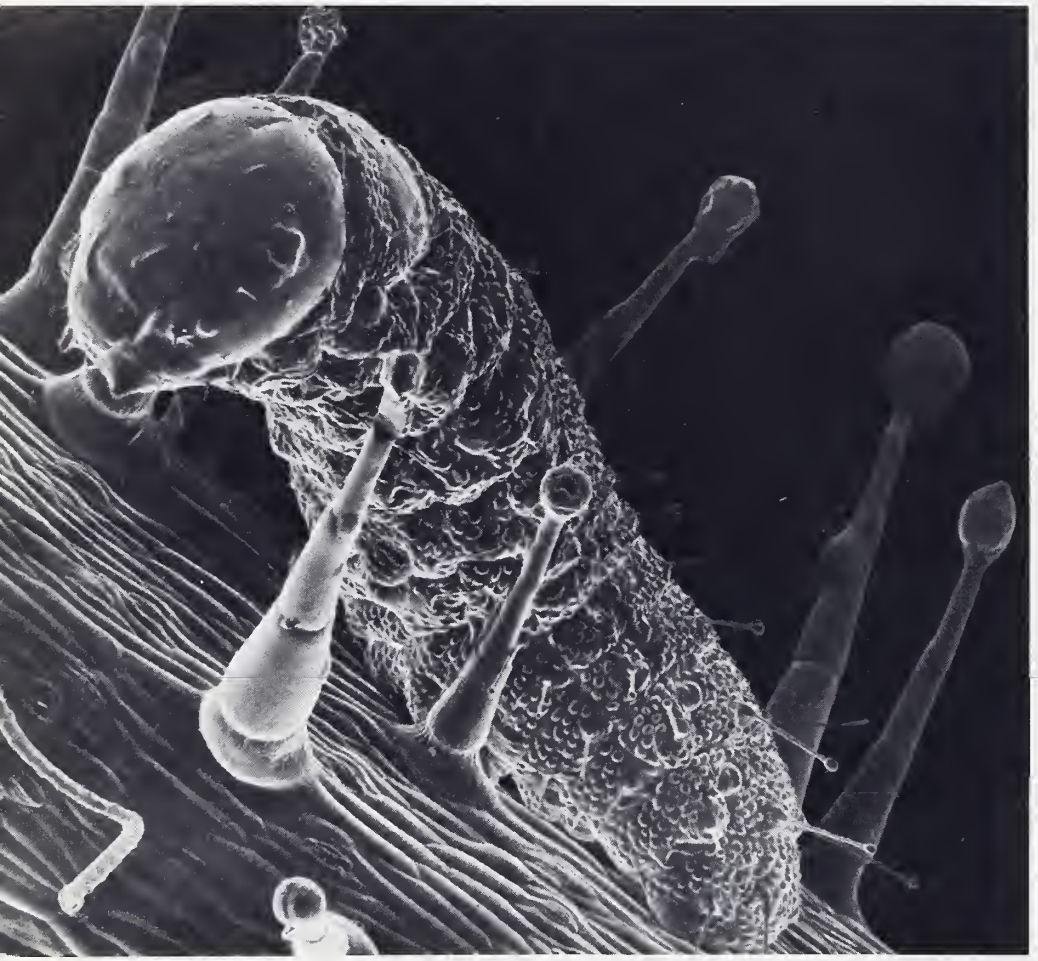
Most trash screens do not work well because the debris is not automatically removed as the screen becomes clogged. Irrigators have to police their screens several times a day and manually clear them. Mechanical systems featuring moving brushes to sweep trash from screens have been reasonably effective, but they require considerable maintenance and frequent replacement of movable parts to remain in operation.

Another problem for irrigators is weed seed. In many cultivated fields, most of the weed growth is a result of seed carried in by the irrigation water. Kemper and Bondurant are now testing turbulent fountain screens to determine what size mesh will capture weed seed as well as trash.

At a field day demonstration, Bondurant (right) explains to local farmers how different-size screen openings filter out various types of trash. In the background, farmers examine portable models of the screen. (0782X763-6)

W. Doral Kemper and James A. Bondurant are located at the Snake River Conservation Research Center, Rt. 1, Box 186, Kimberly, Idaho 83341.—(By Lynn Yarris, Oakland, Calif.) ■

Hairy, Sticky Alfalfa Fights Off Insects



Above: Photographed through a scanning electron microscope, an alfalfa weevil larva is fatally trapped in the sticky hairs of an alfalfa plant variety being developed for eventual use on farms. Actual size of the larva is approximately 1.3 mm, or 1/20 inch long. (PN-7056)

Above right: The adult alfalfa weevil (about 3 mm, or 1/10 inch long) lays its eggs in the fall. If laid on a glandular alfalfa, the eggs will hatch into soon-immobilized larvae. (0683X749-13A)

If ARS research agronomist Edgar L. Sorensen has his way, insect pests of alfalfa will someday find a sticky, barbed-wire entanglement of hair between them and the plant parts they want to feed or lay eggs on.

He has been testing, breeding, and evaluating hairy alfalfas in an effort to develop the plant's physiological defenses against the alfalfa weevil and the potato leafhopper, the two most serious insect pests of alfalfa, as well as against such other pests as spider mites, spotted aphids, and the alfalfa seed chalcid.

Working with entomologists Kathleen J.R. Johnson, Texas A&M, and Ernst K. Horber, Kansas State University, Sorensen compared annual alfalfas from Argentina, Australia, and Turkey, as well as perennial alfalfas.

"We have two good prospects coming along based on crosses to our hay-type lines—one with a wild alfalfa from Russia, *Medicago glutinosa,* and the other with a glandular-haired wild Italian afalfa, *Medicago prostrata,* that is very drought resistant," he says.

Three backcrosses have been made to transfer the glandular hairs to desirable hay-type alfalfas, Sorensen says. After each backcross, several cycles of selection are required to regain hair density, much of which is lost in the backcross. "It is a complex and time-consuming process," he says.

Evaluation of the different kinds of alfalfa hair, and tests with insect pests of alfalfa, have shown that some alfalfas, especially some of the annuals, have very effective, erect, glandular hairs on the stem and leaves that apparently are designed to keep insects under control. An annual pasture alfalfa from Australia, *Medicago scutellata,* showed up as one of the most effective species.

The glandular hairs produce a sticky fluid which builds up in the tip of the hair, breaks out, and runs down. This creates a real problem for young insects—they are quite fragile and when they try to move to the succulent young tip of the leaf they quickly become fatally entangled.

"There are other resistant characteristics at work besides the sticky hairs," he says. "In some of our tests adult alfalfa weevils were given a free choice to select their favorite alfalfa. They avoided the annual species until the common hay types were decimated.

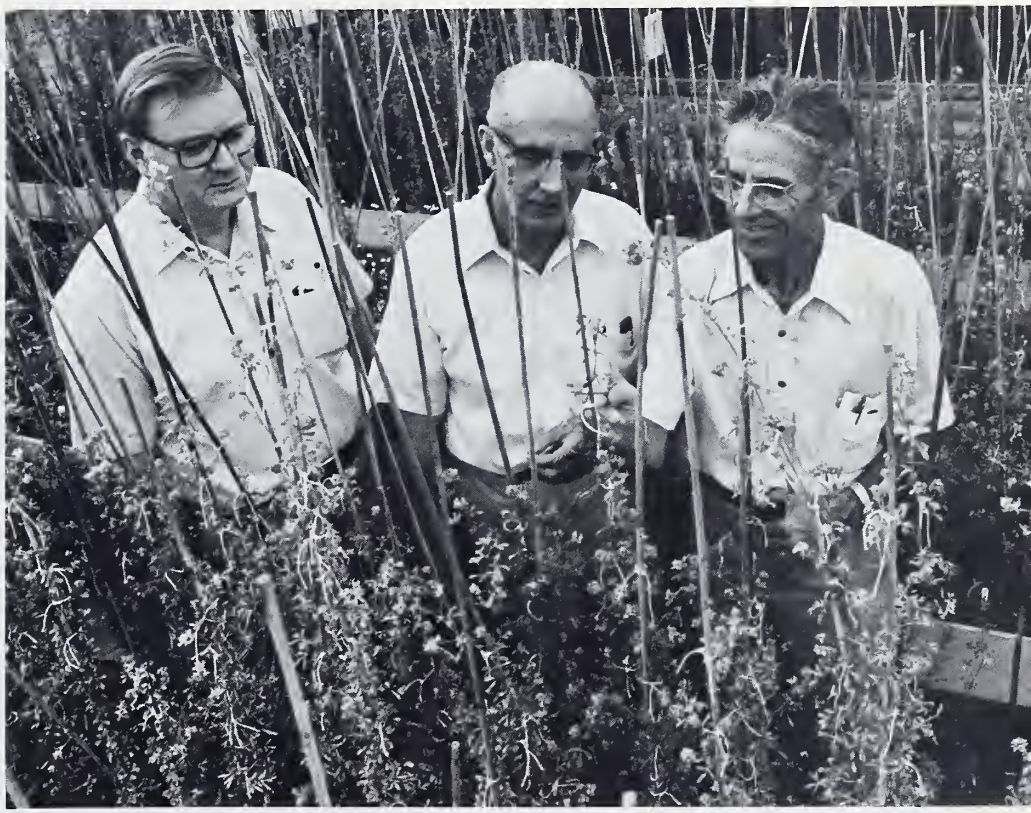
Apparently some factor such as odor was influencing their behavior."

The scientists are studying differences in hairs and the quality and quantity of the sticky exudate from the various *Medicago* lines.

The location of hairs on the plant is also critical, Sorensen says, because each insect has a different style of attack. The alfalfa seed chalcid, for example, injects its eggs into the seed pod, where it hatches and feeds, safe not only from leaf hairs, but also from insecticide applications. So, a hairy seed pod is needed to keep the adult chalcid from laying eggs on it.

The ultimate goal is to breed an alfalfa for use in the Southern Plains that has resistance not only to the important insects, but also to the diseases in the area. (See "Breeding for Hairy, Sticky Alfalfa," next column.)

Edgar L. Sorensen is located in Rm. 146-E, Waters Hall, Dept. of Agronomy, Kansas State University, Manhattan, Kans. 66505.—(By Ray Pierce, Peoria, Ill.) ■



ARS agronomist Edgar Sorensen (center), plant pathologist Donald Stuteville of Kansas State University (left), and entomologist Ernst Hober (also of KSU) evaluate hybrid alfalfa plants for glandular hair density. (0883X1047-14)

Breeding for Hairy, Sticky Alfalfa

The first known cross of annual and perennial *Medicago* species has been made in an effort to improve insect resistance in alfalfa.

"The main characteristic we are trying to transfer is the insect-resistant glandular hairs of the Australian annual pasture type, *Medicago scutellata,* to the hay-type perennial alfalfa, *Medicago sativa,*" says Edgar L. Sorensen, ARS agronomist.

Sorensen, along with Kansas State University cytogeneticist G. H. Liang, and graduate assistant N. Sangduen, produced one hybrid plant from the 34 seeds the team collected after hand-fertilizing thousands of alfalfa flowers and treating them with gibberellic acid to improve the chances of successful fertilization.

Plants require matching numbers of chromosomes to cross successfully.

As they seek to breed a perennial hay-type alfalfa with sticky, insect-resistant hairs, Stuteville (left) and Sorensen also check seedlings for disease resistance. (0883X1046-9)

Even then, wide crosses between plants with different characteristics, though they are in the same genus, are difficult.

"Both the annual and the perennial parents in this case carried four sets of chromosomes, called tetraploids," Sorensen says. "However, cells from our hybrid plant showed six sets of chromosomes, a hexaploid. Samples taken later from a new shoot and from tip cells of the hybrid showed four sets of chromosomes, like the parent plants. This mixture of chromosome numbers in shoots of the same plant, called a mixoploid, is very unusual."

"Unfortunately," Sorensen says, "the hybrid plant could not produce seed from self-fertilization or from crossing with the annual parent. However, we were able to produce viable seeds by fertilizing the tetraploid hybrid plant blossoms with pollen from perennial plants."

The plant shows mixed characteristics, Sorensen says. It has light green color like the annual parent, purple flower color like the perennial parent, and intermediate characteristics in leaf shape and size, degree of hairiness, and stem height and shape.—*(R.P.)* ■

Saving Water in the Southeast

Top: Soil scientist Wendel Gilliam of North Carolina State University checks the privately patented fabridam as it fills with Mitchell Creek water. When water inside the dam reaches a preset level, the rubber-coated nylon structure automatically collapses to allow unrestricted flow. (0883X1035-12)

Above. The sandy farmland surrounding Mitchell Creek near Tarboro, N.C., has yielded up to 40 more bushels of corn per acre since the installation of a fabridam (lower center) as part of a large-scale water management research project involving USDA's ARS and SCS (Soil Conservation Service), the North Carolina Agricultural Research Service, private industry, and local farmers and landowners. (0883X1037-9)

Controlling stream water levels to, in turn, control the water table under the soil holds promise for overcoming seasonal drought that affects 12 million acres of sandy soil along the Atlantic seaboard and cuts yields of soybeans and corn up to 20 percent.

In turn, developing systems to control stream water levels—and also provide normal channel flows during flooding, drainage during wet periods, and stable water table levels during dry periods—is a challenge that calls for new designs.

Working with this concept and some new designs, ARS agricultural engineer Coy W. Doty is raising stream water levels with a collapsible fabric dam, commonly called a 'fabridam.' It was developed according to specifications prepared by ARS and Soil Conservation Service engineers, and patented and built by a private firm in Burbank, Calif.

The fabridam is made of a two-ply, rubber-coated nylon fabric bolted to concrete pads which are placed in stream bottoms and on sides of channel banks.

"The fabric forms a cavity which then fills with water," says Doty. "The water level in this cavity can be controlled automatically with electronic and float-controlled switches and valves. Thus, the dam can either retard the flow of water or allow water to pass, depending on the level automatically maintained in the cavity."

A fabridam installed by ARS in Mitchell Creek in Tarboro, N.C., raised the creek levels about 8 feet, providing water for crop needs and irrigation of adjacent land. One farmer's yields increased about 25 percent in 1982, when additional irrigation water was supplied from this source.

Another promising method for saving water is the use of shallow drainage channels.

"The water-holding capacity of sandy soils in the Southeast supplies crops with enough water for only 5 to 7 days," Doty says, "so when sandy soils are drained too deeply, rain must occur within 5 to 7 days to prevent drought stress to crops."

"Our water management study shows that excessive drainage near deep channels reduces corn yields. Farther away from the deep channel, the drainage is less severe and yields increase 1 bushel for every 40 feet of distance.

Above left: Hassel Thigpen (left), one of 14 local farmers and landowners cooperating with State and Federal researchers in their evaluation of groundwater management systems, discusses data from a water table monitoring station with State conservation engineer Bob Jessup. (0883X1034-28)

Left: North Carolina State research technician Tommy Cone prepares a chart recorder to take depth measurements at a drainage canal intersecting Mitchell Creek about 3,500 feet above the fabridam. The water at this point is nearly 7 feet deep. Prior to installation of the fabridam, it was less than 2 feet deep. (0883X1036-3A)

Above: The costly effects of insufficient groundwater are demonstrated in the stunted growth of these peanut plants being inspected by Mitchell Creek project leader Coy Doty. (0883X1035-29A)

In fact, at a point about 1,500 feet from Mitchell Creek, corn yields increased by 25 percent.

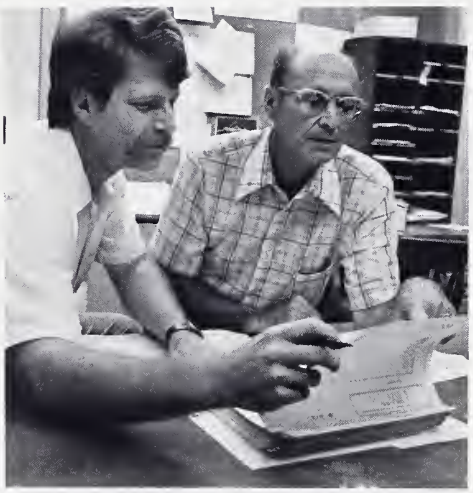
Sandy and organic soils comprise almost 9 million acres of farmland in North Carolina, South Carolina, Georgia, Florida, and Alabama. These Southeastern farmlands need water tables within 3 feet of the soil to provide adequate aeration and moisture to sustain crops and keep highly organic soils from decomposing too rapidly," states Doty.

Farther north, in Virginia, Maryland, Delaware, and New Jersey are another 3.7 million acres of sandy soil with similar problems, Doty says.

"With fabridams and shallow drainage channels, we have found two energy-efficient ways for farmers to regulate the water table, conserve water, and increase crop yields.

"Further research needs to determine what other kinds of structures are most effective and economical for controlling water tables within watersheds," says Doty

ARS is studying these methods as part of a joint Federal, State, and landowner project to develop new engineering criteria for future planning of water resource projects. Scientists of the Soil Conservation Service and ARS scientists at North Carolina State University have been collaborating with Doty on this research.



Top: In addition to raising groundwater tables, installation of the fabridam at Mitchell Creek permitted the use of pivot irrigation sytems on area farms for the first time. (0883X1036-7A)

Above: ARS engineer John Parsons (left) and State conservation engineer Bob Jessup review data generated by a computer simulation model of water table levels near Mitchell Creek. (0883X1037-29)

Coy W. Doty is located at the Coastal Plains Soil and Water Conservation Research Center, P.O. Box 3039, Florence, S.C. 29502.—(By Neal Duncan, New Orleans, La.) ■

Processors Have Fruit Purees "In the Bag"

Exportation and sale of tropical fruit purees from Hawaii is accelerating considerably with the recent development of a processing-packaging system that, among other things, requires no refrigeration.

Called aseptic processing, the system uses a rapid heat treatment followed by rapid cooling to sterilize the puree. It is then, under sterile conditions, filled into presterilized, flexible, plastic-film bags contained in fiberboard cartons and sealed under the same sterile conditions.

The aseptic bag is made of two layers, one of which is polyethylene and the other a metalized plastic. The product is stable at room temperature.

The standard methods of processing purees—freezing and canning—have some disadvantages. The canning process results in significant color, flavor, and nutrient losses due to the severe heat treatment. Also, the process requires that no larger than 1-gallon cans be used.

Frozen products, although retaining color, flavor, and nutrients, are costly to process, store, and transport due to escalating energy costs. Marketing of frozen purees is limited to users with the capability for handling frozen products. The freezing method also limits container size to 35–40 pounds.

ARS food technologist Harvey T. Chan, Jr., who, along with Catherine G. Cavaletto of the University of Hawaii, developed the aseptic process for papaya and guava, says it has several important advantages over present methods. Some of the advantages are:

- Lower processing costs than freezing;
- Lower storage costs than freezing;
- Lower transportation costs than freezing;
- Better flavor, color, and nutrient retention than freezing;
- Wider distribution and marketing possibilities;
- Potential for bulk packaging—up to 300 pounds;
- No refrigeration required.

Application of aseptic bag-in-box packaging with guava puree has shown that there is no flavor loss due to aseptic processing, and only slight flavor loss after 6 months' storage. There is

some color loss during processing which continues during 6 months' storage, resulting in color that is significantly less pink than frozen puree after the same period. There is no vitamin C loss after processing, 70 percent vitamin C retention after 6 months, and no microbial spoilage in that time.

Papaya puree that goes through the aseptic process shows essentially the same effects as guava. There is no flavor loss, and the color change is slight and does not affect the overall appearance. Vitamin C retention is 94 percent after processing, with 44 percent vitamin C retention after 6 months, and no microbial spoilage.

All in all, the equipment required for puree production is about the same regardless of the processing system used, Chan says.

That means, then, that savings are realized by variable rather than fixed costs. Variable costs break down to:

- Labor—about the same for aseptic as for freezing;
- Processing—energy costs for heating and cooling reduced by about 30 percent, saving about 2 cents per pound compared to freezing;
- Packaging—costs are 50 percent under those for canning, slightly higher than those for frozen;
- Storage—about 2 cents per pound savings over frozen;
- Transportation—savings of about 1.8 cents compared to frozen purees shipped to the West Coast.

A plant processing 6,500 pounds of puree an hour would save hundreds of thousands of dollars a year with the use of an aseptic processing system, Chan says.

Purees are used in the manufacture of yogurts, fruit drinks, fruit toppings, dried fruit leathers, jams and jellies, and confections.

Harvey T. Chan, Jr., is located at the Tropical Fruit and Vegetable Research Laboratory, Waiakea Farm, Hilo, Hawaii 96720. Catherine G. Cavaletto is located at the Dept. of Horticulture, University of Hawaii, Honolulu, Hawaii 96804.—(By Paul Dean, Oakland, Calif.) ■

Arthritis in Goats—A Model for the Human Ailment?

Medical researchers have long thought—but never been able to prove—that rheumatoid arthritis may be caused by a mysterious virus that is gone by the time the disease's crippling symptoms appear. Now, ARS scientists have identified a virus responsible for a similar disease in goats and are investigating its potential as a model for the human ailment.

Caprine arthritis-encephalitis (CAE), sometimes called "big knee disease," may infect more than 80 percent of the U.S. domestic dairy goat population. Although the disease surfaced in the 1960's, not until 1977 was its cause identified as a retrovirus—a virus that persists throughout the life of the host and produces the disease only after a long incubation.

"This is the only virus to date that's been proven to cause chronic arthritis in a mammal," says veterinary researcher D. Scott Adams, Pullman, Wash., who led the team of researchers making the discovery.

Adams believes that CAE virus in goats can serve as a model for rheumatoid arthritis in humans and that a better understanding of one could lead to a better understanding of the other. Adams and his team at WSU are working with the rheumatology section of the University of Washington's medical school in Seattle.

"Though a vaccine against CAE has yet to be found," says Adam, "control measures have been developed."

CAE is transmitted to newborn goat kids mainly through colostrum and milk from infected mothers. Adams' research team has found that heat can kill the virus without harming protective antibodies in the colostrum. (Though pasteurization and subsequent processing inactivate the CAE virus, there is no proof that CAE is not transmissible to humans.)

"Separating kids from their mothers at birth and feeding them colostrum that has been heated for 1 hour at 56°C (133°F), and pasteurized milk until they are weaned, prevents further infections and can eventually eradicate the disease from a herd," says Adams. Contact between does and kids should be kept to a minimum, he adds, as

A goat suffering from caprine arthritis-encephalitis, also known as "big knee disease." (PN-7063)

some transmission could occur through a mother's saliva and other secretions. "Uninfected goats should be kept separate from infected goats as much as possible for the same reason."

CAE-infected adult goats may suffer from the swollen, disfigured joints of arthritis, and kids may show symptoms of encephalitis and progressive paralysis. However, only a few goats—about 3 percent in this country—ever show any signs at all of the disease. But even without symptoms, infected goats can transmit CAE, creating a major problem for the U.S. goat industry. Developing nations that import goats from the United States have a low prevalence of the disease and are anxious not to see their fortune changed.

A situation recently arose where symptom-free but CAE-infected goats from the United States were accidentally introduced into Kenya as part of an aid program to improve goat production. Three years later a large proportion of the goats developed CAE disease and the U.S. Government sent Adams there to help. Using procedures developed in the experiments of his research team, he was able to bring the disease under control and prevent it from spreading to Kenyan herds.

D. Scott Adams is located at Washington State University, Veterinary Science Bldg., Pullman, Wash. 99164.—(By Lynn Yarris, Oakland, Calif.) ■

Long-Term Study Clears Soy Protein

Results of a long-term study on how added soy protein in ground beef affects people's iron status has eased concerns caused by findings of earlier tests.

A 6-month study of 227 adults and children fed a diet containing soy protein found that iron levels in the blood either improved or were not significantly changed.

The study was conducted by research chemists C. E. Bodwell and Eugene R. Morris, research nutrition scientist Carolyn W. Miles, and colleagues at the ARS Human Nutrition Research Center, Beltsville, Md.

These findings counter several earlier nutrition studies which suggested a health risk from soy proteins. The earlier results were based on single-meal tests, and indicated that soy proteins, when used to extend ground beef, reduced human absorption of dietary iron up to 61 percent. Soy protein is widely used in the United States in meals provided by the military, in school lunches, baby formulas, and many diet supplements.

The research team investigated three of the most common soy protein preparations. These were textured soy flour, soy protein isolate, and soy concentrate. In addition, the study analyzed the possible benefits of fortifying soy proteins with dietary iron or zinc.

To examine the nutritional impact on iron status under practical conditions, Bodwell and his colleagues studied 52 households in the District of Columbia, Maryland, and Virginia. Other volunteers were selected as a control group for monitoring normal variations in absorption of dietary iron.

After passing through an initial complete blood analysis and medical evaluation, the 227 participants continued their usual lives as much as possible during the study. Each family received especially prepared meat patties to provide the protein in seven to nine meals each week. Seven kinds of patties were tested—all-beef; beef with three types of soy protein; and beef with three soy proteins fortified with iron and zinc. Blood samples were taken in order to measure the blood levels of ferritin—the body's iron storage protein—at 45-day intervals throughout the 6-month study. At the end of the study another complete blood analysis was done on each volunteer.

Adult male volunteers also participated in two absorption tests in which they consumed meals specially labeled with a radioactive isotope of iron. The absorption tests are considered very accurate and serve as a check measurement for the ferritin analysis, Bodwell says.

The patties (except all-beef) were prepared with 20 percent soy protein and 80 percent protein from beef. Bodwell noted that this is about the same ratio specified for U.S. Department of Defense ground beef purchases. The U.S. Department of Agriculture's National School Lunch Program—which provides about 23 million lunches per school day—allows soy to be used as a replacement for up to 30 percent of ground meat.

"Neither the DOD nor the School Lunch level, Bodwell says, appears to present a risk of a soy-induced iron or zinc deficiency."

C.E. Bodwell, Eugene R. Morris, and Carolyn W. Miles are located at the Human Nutrition Research Center, Bldg. 308, Beltsville Agricultural Research Center-East, Beltsville, Md. 20705.—(By Lloyd McLaughlin, Beltsville, Md.) ■

Science and Our Resource Heritage

Reducing Irrigation on Winter Wheat

When soil water storage is adequate at seeding time, withholding irrigation water from winter wheat at various growth stages has no influence on grain yield. Previous research had indicated that winter wheat is sensitive to water stress at different growth stages.

In studies at the Central Great Plains Research Station, Akron, Colo., ARS agronomist Bohn Dunbar and extension irrigation management specialist R. Wayne Shawcroft withheld or applied irrigation water during either spring vegetative, heading-flowering, or grain-filling stages.

Plots receiving a total of 10 inches of irrigation water produced an average of 69 bushes per acre regardless of when water was applied or withheld. The control plots, however, which had approximately 10 inches of water stored in the soil at planting and which were not irrigated, averaged only 45 bushels. The test plots of winter wheat were grown under an automatic shelter that covered the plots to exclude natural rainfall.

The scientists are seeking farming strategies for the High Plains that would improve farm incomes while reducing water use. This might include switching to limited-irrigation wheat as an alternative to traditionally irrigated crops, such as corn, which require more water.

Bohn Dunbar and R. Wayne Shawcroft are located at the Central Great Plains Research Station, P.O. Box K, Akron, Colo. 80720.—(By Dennis Senft, Oakland, Calif.) ■

Longstanding Theory on Vapor Movement Upset

To determine dispersion rates for different pesticides, ARS chemist Dwight Glotfelty (left) and laboratory chief Alan Taylor devised this sampling mast to collect pesticide vapors at selected heights above a treated field. (0883X1051-10A)

A 63-year-old theory on the movement of gases in our atmosphere has been brought into question by the results of a 3-year study.

After working with mixtures of pesticide vapors since 1980, three chemists have concluded that vapor movement is controlled not only by air currents, as was formerly thought, but can also depend on the weight and size of the molecules involved.

The researchers are ARS chemist Dwight E. Glotfelty and laboratory chief Alan W. Taylor, both of the Soil Nitrogen and Environmental Chemistry laboratory, Beltsville, Md., and William H. Zoller of the University of Maryland Chemistry Department.

The team discovered the unexpected behavior of vapors while conducting field experiments to measure how much pesticides vaporize after the compounds are applied to the ground. They worked with six pesticides having a range of molecular weights and sizes from the small, two-dimensional molecule of the herbicide trifluralin to the large, three-dimensional structure of the insecticide dieldrin. The discovery has "major implications in micrometeorology, atmospheric chemistry, and air pollution," the researchers report.

Scientists have long known that small, light gas molecules diffuse faster than large, heavy ones. But because air currents carry molecules 1,000 to 10,000 times faster than they can move under their own energy, classical theories have assumed that diffusion did not play any significant role in the movement of molecules in the atmosphere, Glotfelty explains. Theory held that mixtures of gases remain confined in air pockets where they are pushed along and diluted by the wind.

Not so, say the scientists. Instead, they hypothesize that mixed gases are drawn out into a thin layer or sheet between layers of air currents. With this larger surface area, the molecules are freer to diffuse according to their size and weight.

The new theory will be controversial and will have to be verified by other researchers, Glotfelty says. If verified, however, "earlier views about the way gases disperse in the atmosphere must be radically revised."

For example, scientists use tracers—inert gases that don't decompose or react with other chemicals—to study the movement of air and to help determine air quality. By releasing a tracer from a tall smoke stack and recovering it in a series of downwind detectors, one can learn how air masses soar and dive and where they touch down. If the tracer is released with an air pollutant, one can estimate the fate of the pollutant during its airborne travels: the difference in the ratio between the released gases and the recovered gases indicates how much of the pollutant decomposed, reacted with other chemicals, or just settled out. Such estimates have been based on the belief that the tracer and the pollutant moved together. According to the new theory, however, the tracer may not move or dilute at the same rate as the pollutant, particularly if its molecular structure differs in weight and shape.

The diffusion factor will affect many areas of atmospheric research including cloud physics, atmospheric chemistry, and deposition of airborne chemicals on the earth's surface. In developing mathematical models to describe these processes, scientists use coefficients based on the 63-year-old theory of vapor movement. Although air currents are the prime movers of atmospheric vapors, diffusion must be taken into account when interpreting atmospheric data and making predictions. "It is a coupled process in which both are involved," Glotfelty says.

The implications of the new theory are not all negative, however. Glotfelty speculates that the findings might serve as a basis for new methods of separating gaseous chemicals—both on a large scale in manufacturing processes and on a minute scale in analytical instruments. It could also be important in the biological sciences—for instance, in explaining the subtleties of how insects communicate with one another through chemical attractants known as pheromones.

During the 3-year study, the team trapped and analyzed more than 3,000 samples of airborne pesticide vapors. They sprayed mixtures of two or more pesticides on a fallow field and collected vapor profiles 74 to 174 yards downwind with 12 polyurethane foam samplers affixed to a sampling mast at heights between 2 inches and 6 feet above ground level. The mast also carried instruments for measuring wind speed and temperature. When Glotfelty analyzed the data, he realized that the vapor profiles consistently showed rapid shifts in the proportions of these pesticides. After thoroughly checking and discrediting all other possibilities, such as sun-induced decomposition, adsorption to airborne particles, instrument error, or interference from air cross currents, the researchers concluded that the pesticides with smaller molecules had indeed risen through the sampling zone faster than the larger ones.

Dwight E. Glotfelty and Alan W. Taylor are located at the Soil Nitrogen and Environmental Chemistry Laboratory, Bldg. 007, Beltsville Agricultural Research Center-West, Beltsville, Md. 20705. William H. Zoller is located in the Chemistry Dept., University of Maryland, College Park, Md.—(By Judy McBride, Beltsville, Md.) ■

Fumigating Empty Metal Grain Bins

Typical farm grain bins. (PN-7064)

The space under grain bins with perforated floors for drying and aeration provides a perfect home for insects.

"Broken kernels, dust, and chaff fall through the floor and make an ideal environment for insects," says James K. Quinlan, research entomologist at the ARS Grain Marketing Research Laboratory, Manhattan, Kans. "Usually the bin floors are not easy to remove, making it difficult to clean or spray the area below the floor."

Quinlan and research entomologist William H. McGaughey determined that fumigation might be a likely solution. They tested four fumigants for control of red flour beetle adults and eggs, and immature stages of the rice weevil, in empty 3,250-bushel circular metal bins.

They tested chloropicrin, phosphine, carbon tetrachloride with carbon disulfide, and ethylene dichloride with carbon tetrachloride and ethylene dibromide. Chloropicrin is labeled for fumigation of empty grain bins, the other materials are not. Phosphine was used in tablet form, the others in liquid form.

Test cages of insects were placed in cotton bags containing cracked corn. Bags were placed under the perforated floor, on the floor of the bin, and suspended 4 feet above the floor. The bins had galvanized steel perforated floors supported by concrete blocks 1 foot above a concrete subfloor. Bin doors, fan openings, auger and roof vents were sealed with masking tape and polyethylene when treatments were applied.

Mortality counts were made on adult insects following the 48-hour fumigation period and larvae counts were made 4 and 6 weeks after treatment.

The chloropicrin at 16 liquid ounces per bin, one-half the rate called for on the label, did not do an adequate job, Quinlan says, but the recommended 32-ounce application killed all stages of the test insects on and below the floor. Some of the insects suspended above the floor survived.

An application of 2 gallons of ethylene dichloride-carbon tetrachloride-ethylene dibromide also produced 100 percent mortality of all stages of insects except those suspended above the floor.

Phosphine was effective only when a plastic sheet was placed over the perforated floor and a 60-tablet dose was used. The carbon tetrachloride with carbon disulfide combination was not effective, Quinlan says.

Quinlan points out that chloropicrin is easily applied, is already labeled for use in empty grain bins, and works effectively. He stresses that users should seal all openings around the bin door and fan vents to achieve good results. After 48 hours of fumigation, bins should be opened and aired out for 4 hours before being entered.

James K. Quinlan is located at the U.S. Grain Marketing Research Laboratory, 1515 College Ave., Manhattan, Kans. 66502.—(By Ray Pierce, Peoria, Ill.) ■

Applying Chemicals Through Irrigation Systems

Chemigation, the application of agrichemicals to plants through existing irrigation systems, may potentially increase the efficiency of irrigated crop production.

"This form of irrigated agriculture offers the farmer uniform distribution of agrichemicals at less cost, multiple use of expensive irrigation systems, minimized soil compaction, reduced environmental pollution, and lower energy expenditures," says Norman C. Glaze, ARS plant physiologist, Tifton, Ga. "Moreover, chemigation is independent of weather conditions.

"Intended crop use determines the particular fertility program," he says. "Following soil or plant analyses, the amount of nutrient per application is then determined by soil type and extensiveness of the crop root system."

Glaze acknowledges that the efficiency of any irrigation system in applying herbicides will depend on the efficiency of the system itself. The volatility or solubility of the chemicals themselves will also influence whether application through an irrigation system is feasible or not. For example, studies have shown that the herbicide trifluralin can be ineffective when applied through an irrigation system at normal rates because of its volatility and high loss rate from wet soils.

Glaze stresses that to prevent environmental pollution, certain precautions must be followed. Existing injection pumps and water power sources should be interlocked to assure that both will stop if either one stops. The irrigation system should also have check and vacuum relief valves to keep chemicals from contaminating the water source and to prevent accidental losses should the system malfunction. Pressure switches and solenoid valves appropriately placed in the injection system are also good safety measures, he adds.

"The use of chemigation should increase, and, when monitored closely, should become an integral part of the total crop production package," Glaze says.

Chemigation was developed coopera-

tively by USDA and University of Georgia scientists.

Norman C. Glaze is located at the Georgia Coastal Plain Experiment Station, Tifton, Ga. 31793.—(By Neal Duncan, New Orleans, La.)

No Volunteers, Please!

Volunteers are not always wanted, just ask a potato grower. Volunteer potatoes are the chief source of overwintering potato viruses and of aphids that transmit these viruses to cultivated potato crops.

Growers have been using chemical treatments to discourage these volunteers. Now, however, ARS researchers at Prosser, Wash., have shown that properly timed tillage, in combination with the use of a wheat cover crop, can control the problem as effectively as chemicals and at a much lower cost.

Volunteer potato plants often flourish in wheat and corn fields that have been cropped to potatoes the previous season. Herbicides can control these volunteer populations, but there is a risk to the cereal crops unless the chemicals are used after the grain harvest. By then, however, aphids have already picked up the potato viruses.

The researchers, led by plant pathologist Peter E. Thomas, were able to control volunteer potato populations in the Columbia Basin of the Pacific Northwest by plowing up potato fields after the first winter frost instead of waiting, as usual, until spring.

Says Thomas, "Winter plowing exposed to freezing many tubers that would otherwise have been protected from destruction by burial in the soil."

The idea for this technique came, Thomas says, when he noticed considerable differences in the numbers of volunteer potatoes among fields having the same cropping history.

"In addition to winter plowing," he adds, "we also found that planting a wheat cover crop after plowing reduces the size and vigor of volunteer plants and reduces the number of aphids on these plants."

Peter E. Thomas is located at the Irrigated Agriculture Research Center, P.O. Box 30, Prosser, Wash.—(By Lynn Yarris, Oakland, Calif.) ■

Russian Wildrye is Reclassified

A rose by any other name might smell as sweet, but it would cause a lot of problems for researchers who depend on proper taxonomic classifications of plants and animals to do their work.

Such is the situation for Russian wildrye, a major range grass in western North America that, a recent ARS study reveals, has for many years been misclassified by most users in the United States and Canada.

Fundamental to orderly science is a taxonomic system that accurately reflects biological relationships. On this continent, Russian wildrye has been identified as *Elymus junceus*. But now, new cytogenic data gathered by research geneticist Douglas R. Dewey and botanist Catherine T. Hsiao, Logan, Utah, show the plant as belonging not to the *Elymus* genus but the the *Psathyrostachys* genus, and should correctly be identified as *P. junceus*.

Says Dewey, "Our data leave no doubt that Russian wildrye and *P. fragilis* are closely related and should be placed in the same genus." The name *P. junceus,* Dewey notes, is commonly used now by European and Asian researchers, and has been recommended by botanists at ARS' Plant Taxonomy Laboratory at Beltsville, Md.

Introduced into the United States in 1927, Russian wildrye was not fully recognized for its importance in revegetating depleted rangelands until the 1950's. Much research has been conducted on the plant since then, both in the United States and Canada, but always under the name *E. junceus*.

Douglas R. Dewey and Catherine T. Hsiao are located at the Crops Research Laboratory, Utah State University, UMC 63, Logan, Utah 84332.—(By Lynn Yarris, Oakland, Calif.) ■

Rabbiteye Blueberries Return

Rabbiteye blueberries are staging a horticulturally induced, commercially important comeback. At one time, this small, black, and gritty-fleshed berry was considered so lacking in flavor that commercial planting was abandoned.

Russian wildrye under study at the ARS Livestock and Range Research Laboratory, Miles City, Mont. (0782X830-5)

Today, as a result of breeding and the varieties developed by ARS and the Universities of Georgia and Florida and North Carolina State University, the berry's size, color, and quality have improved and commercial rabbiteye blueberry planting in the South is expanding (see *Agricultural Research,* Sept. 1977, p. 15, Dec. 1977, p. 13, Nov. 1978, p. 17).

Georgia has the most acreage (2,000 acres planted), with over 300 acres in production as of 1980. Florida has from 200 to 300 acres consisting almost entirely of "pick-your-own" operations. North Carolina has about 200 acres grown in small commercial plantings and "pick-your-own" operations. Other Southern States have less acreage in production, but plantings are increasing rapidly. It is estimated that from 200 to 500 acres will be in production by 1985 in Mississippi, Louisiana, and Alabama.

In an effort to expand production, James M. Spiers, a research horticulturist with the ARS Small Fruit Research Station in Poplarville, Miss., is conducting studies to determine the effects of first-year fertilization and addition of organic matter on the survival and early growth of rabbiteye blueberry plants. The test plots are being grown in fine sandy loam, the soil type prevalent in the lower coastal plains region of Mississippi, Louisiana, and Alabama.

Spiers reports that the addition of peat moss (as well as of other types of organic matter) increases plant vigor and reduces yellowing of leaves. However, first- and second-year plant growth and second-year fruit yields are reduced by first-year fertilization. This response occurs with either a slow- or a fast-

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release granulated fertilizer. Soluble fertilizers produce less plant damage than granulated fertilizers, but do not promote any increase in plant growth over no fertilization. There was a close association between overfertilization and yellowing of leaves.

The studies indicate that plants grown with peat moss are superior to plants grown with pine sawdust or pine bark. When rabbiteye blueberries are grown in this or similar soil types under irrigation with organic matter, usually no fertilization should be needed the first growing year.

James M. Spiers is located at the Small Fruit Research Station, P.O. Box 287, Poplarville, Miss. 39470.—(By Neal Duncan, New Orleans, La.) ■

Erosion High After Row-Cropped Soybeans

How do soybeans affect erosion in rotations with corn?

Not so well, says John M. Laflen, ARS agricultural engineer, Ames, Iowa. He measured soil and water losses over a 7-year period at Beaconsfield, Iowa. Soil losses when corn followed soybeans averaged 4.3 tons per acre from spring plowing to spring plowing. Soil losses when corn followed corn were 3.1 tons per acre. When soybeans followed corn, losses averaged 2.9 tons per acre.

"Apparently, soybeans left the soil more susceptible to soil erosion during the following cropping season than did corn," Laflen says.

Soil is lost as sediment carried in runoff water, so the amount lost is closely related to the volume of water than runs off the field. Water loss from corn after soybeans averaged about 13 percent more than from corn after corn. Sediment concentrations in runoff water from corn after soybeans averaged about 20 percent more than in runoff from corn after corn.

"Based on the results of this study, under continuous row-cropping conditions, soil losses from corn following soybeans would exceed losses from soybeans following corn or from corn following corn by more than 40 percent," he says.

The study was on a Grundy silt loam soil that had a 6-percent slope. Conventional tillage systems were used.

"While erosion on crops grown after soybeans may be considerably greater than from crops following corn, good erosion control might be achieved by wise use of a conservation tillage system," Laflen say. "For example, other research by our USDA research team at Ames has shown that soybean residues will provide good erosion protection if no-till planting into soybean residues is used."

John M. Laflen is located at Iowa State University, Davidson Hall, Rm. 211, Ames, Iowa 50011.—(By Ray Pierce, Peoria, Ill.) ■